

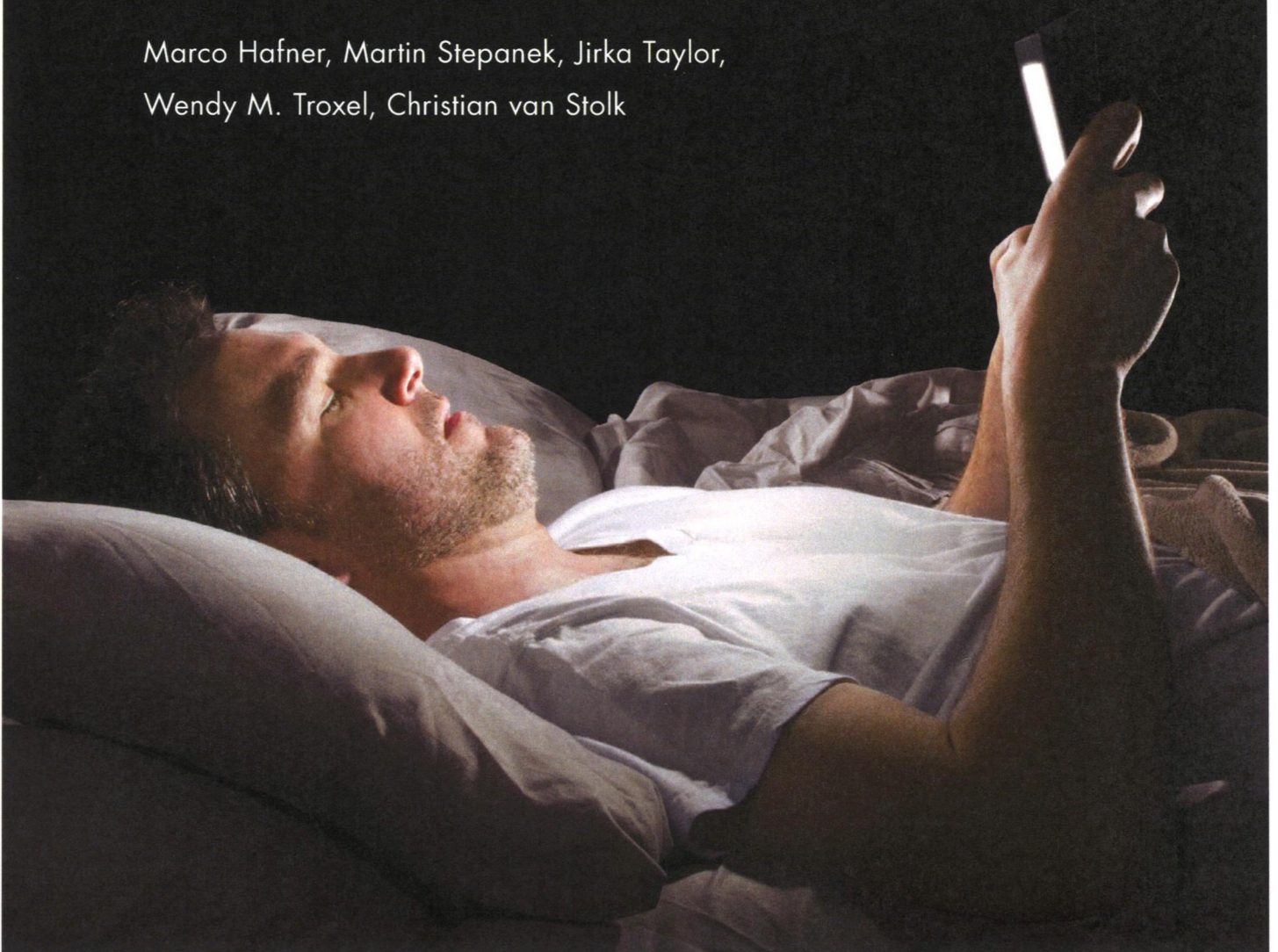


RAND EUROPE

# Why sleep matters – the economic costs of insufficient sleep

A cross-country comparative analysis

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## Preface

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This report presents the findings of a study on the causes, consequences and related economic costs of insufficient sleep.

The report will be of interest to employers, policy-makers, and the wider society and people interested in the field of sleep, health and wellbeing and health economics in general.

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## Executive summary

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### A. Insufficient sleep as a public health problem

The Centers for Disease Control and Prevention (CDC) in the United States has declared insufficient sleep a 'public health problem'. Indeed, according to a recent CDC study, more than a third of American adults are not getting enough sleep on a regular basis (Liu et al., 2014). However, insufficient sleep is not exclusively a U.S. problem, and also concerns other industrialised countries such as the United Kingdom, Japan, Germany, or Canada (National Sleep Foundation, 2013). According to recent evidence, the proportion of people getting less than the recommended hours of sleep is rising and is associated with lifestyle factors related to a modern 24/7 society, such as psychosocial stress, unbalanced diet, lack of physical activity and excessive electronic media use, among others (Roenneberg, 2013). This is alarming as insufficient sleep has been found to be associated with a range of negative health and social outcomes, including adverse performance effects at school and in the labour market.

Insufficient sleep duration has been linked with seven of the fifteen leading causes of death in the United States, including cardiovascular disease, malignant neoplasm, cerebrovascular disease, accidents, diabetes, septicaemia and hypertension (Kochanek et al., 2014). Besides impairing health and wellbeing, existing evidence suggests that sleep plays an important part in determining cognitive performance and workplace productivity, with a lack of sleep leading to more traffic accidents, industrial accidents, medical errors and loss of work productivity (Nuckols et al., 2009; Ulmer et al., 2009; Pack et al., 1995). Sleep loss and sleep-related disorders have been linked to a number of accidents and catastrophes including the Chernobyl nuclear explosion, the Three Mile Island nuclear incident, the Exxon Valdez spill and the Space Shuttle Challenger tragedy (United States Senate Committee on Energy and Natural Resources, 1986; Dinges et al., 1989; Moss, 1981; National Commission on Sleep Disorders, 1993; Walsh et al., 2011).

While insufficient sleep can have detrimental impacts on all age cohorts, sleep deprivation among children and adolescents may trigger irreversible long-term consequences. For instance, there is strong evidence for the association of quality and quantity of sleep with school performance and cognitive ability among school-aged children and adolescents (Blunden et al., 2000; Owens et al., 2000; Roberts et al., 2001). However, according to a National Sleep Foundation (2006) survey, more than 87 percent of high school students in the United States get far less than the recommended hours of sleep, and the amount of sleep they get is decreasing, posing a serious threat to their health and academic success.

Given the potential adverse effects of insufficient sleep on health, well-being and productivity, the consequences of sleep-deprivation have far-reaching societal and economic consequences. With the evidence on the economic consequences of sleep loss and disorders being limited so far, there is an acute



need for systematic analyses of the economic impacts of insufficient sleep, particularly given some evidence of rising rates of insufficient sleep worldwide. This research study aims to raise awareness of the scale of insufficient sleep as a societal issue, quantifying the economic costs of insufficient sleep as well as making recommendations and providing potential solutions that can help tackle this growing problem.

## B. Objectives of the study

Against this background, the study aims to stimulate discussion on the economic burden of insufficient sleep by contributing to the evidence base surrounding this public health problem. In essence, building on existing scientific evidence and applying relevant quantitative research methods this study seeks to:

- 1) **Identify the factors associated with sleep duration:** in order to make recommendations on how to tackle the problem of insufficient sleep it is important to understand the factors associated with sleep duration in more detail. To that end, we use a novel large employer-employee dataset which includes a substantial number of different variables that may be associated with sleep duration, enabling us to examine the relative contribution of each factor in more detail.
- 2) **Investigate the link between insufficient sleep and mortality and workplace productivity:** insufficient sleep is associated with many negative health outcomes and elevated mortality risks. It also impairs cognitive performance, leading to lower productivity levels. Using appropriate econometric modelling techniques, this study provides new estimates on the association between insufficient sleep and mortality, as well as working time lost due to absenteeism, employees not being at work, and presenteeism, employees being at work but working at a sub-optimal level.
- 3) **Quantify the economic costs of insufficient sleep across different countries:** we draw on parameters derived in the empirical analysis of this study and conduct a cross-country comparative analysis of the economic burden of insufficient sleep. For this purpose we develop a bespoke macroeconomic model to project GDP and labour productivity for five OECD countries under different future 'what if' scenarios.

## C. Key research findings

The study findings contribute to the existing evidence base in four different areas: (1) factors associated with insufficient sleep; (2) link between insufficient sleep and (all cause)-mortality; (3) association between insufficient sleep and workplace productivity; (4) economics costs of insufficient sleep across five different OECD countries.

### *1. Individual and workplace-related factors impact sleep duration*

Using recent survey data for over 62,000 individuals covering the combined years of 2015 and 2016, the findings of this study suggest that a number of different individual-level and workplace factors are associated with insufficient sleep. This includes body mass index (BMI), smoking, sugary drink consumption, a lack of physical activity, stress and anxiety, financial concerns, gender, marital status, unrealistic time pressures at work, working irregular hours and long commuting times. The factors leading to short sleep can be summarised in more detail as follows:

*Lifestyle and health factors*

- 1) **BMI:** people with a BMI considered as overweight or obese sleep on average between about **2.5 minutes** to **7 minutes** less per day than those with a normal BMI.
- 2) **Smoking:** current smokers sleep on average **5 minutes** less per day than non-smokers.
- 3) **Sugary drinks:** people consuming more than two sugary drinks per day sleep on average **3.4 minutes** less per day than those with less consumption of sugary drinks.
- 4) **Physical activity:** people performing less than 120 minutes of physical activity per week sleep on average about **2.6 minutes** less per day than those reporting to do more than the recommended 150 mins of physical activity per week.
- 5) **Mental health:** people with medium to high risk of mental-health problems sleep on average **17.2 minutes** less per day than those with low risk of mental-health issues.

*Personal and socio-demographic factors*

- 1) **Financial concerns:** people with financial concerns sleep on average about **10 minutes** less per day than those without concerns.
- 2) **Unpaid care:** people who provide unpaid care to family members, close relatives or friends sleep on average about **5 minutes** less per day than those who do not provide unpaid care.
- 3) **Children:** people with dependent children under age of 18 living in the same household sleep on average about **4.2 minutes** less per day than those without dependent children under the age of 18.
- 4) **Gender:** Men sleep on average about **9 minutes** less per day than women.
- 5) **Marital status:** people reporting being separated from their partner sleep on average **6.5 minutes** less per day than those who report being married. Similarly, people who reported never being married sleep on average **4.8 minutes** less than those being married.

*Workplace psychosocial and job factors*

- 1) **Lack of choice:** people reporting a lack of choice in their daily work routine sleep on average **2.3 minutes** less per day than those reporting more choice at work.
- 2) **Unrealistic time pressures:** people reporting unrealistic time pressures and stress at the workplace sleep on average **8 minutes** less per day than those reporting low levels of time pressure.
- 3) **Irregular hours:** people that work irregular hours (e.g. shift work) sleep on average **2.7 minutes** less per day than those working regular hours.
- 4) **Commuting:** people commuting between 30 to 60 minutes to work (one way) sleep on average **9.2 minutes** less per day compared to those with a zero to 15 minutes (one way) commute. Heavy commuters travelling more than 60 minutes to work (one way) sleep on average **16.5 minutes** less per day than those with only short commutes.

At first glance, the estimates of minutes of sleep lost due to the various factors outlined above may seem small. However, it is important to stress that the estimates represent the effect on sleep duration of each single factor, holding all other factors constant.

To put this into perspective, an employee who works irregular hours, commutes 30 to 60 minutes to work (one way) and is exposed to a set of different measures of workplace psychosocial risks, such as unrealistic time pressures, sleeps on average about **28.5 minutes per day** less than an employee that has regular working hours, commutes only up to 15 minutes (one way) and is not exposed to psychosocial risk factors at the workplace. This equates to over **173 hours of lost sleep per year**.

## ***2. Insufficient sleep increases mortality risk by up to 13 per cent***

Investigating the link between sleep duration and mortality we find that at any given point in time, an individual that sleeps on average less than six hours per night has a 13 per cent higher mortality risk than an individual sleeping between seven and nine hours, which is considered as the healthy amount of sleep. Furthermore, an individual sleeping between six and seven hours per night has a 7 per cent higher mortality risk. This includes all causes of death, including fatal car accidents, strokes, cancer or due to cardiovascular disease.

## ***3. Insufficient sleep is costly for employers by reducing workplace productivity***

The empirical findings of this study suggest that workers who sleep less than six hours per day report on average about a 2.4 percentage point higher productivity loss due to absenteeism or presenteeism than workers sleeping between seven to nine hours per day. Those sleeping on average between six to seven hours still report about a 1.5 percentage point higher productivity loss compared to those sleeping seven to nine hours. To put these numbers into perspective, assuming there are 250 working days in a given year, this means that a worker sleeping less than six hours loses around **6 working days** due to absenteeism or presenteeism per year *more* than a worker sleeping seven to nine hours. A person sleeping six to seven hours loses on average about **3.7 working days** *more* per year.

Taking into account observed distributions of sleep duration and different working population sizes across five different OECD countries,<sup>1</sup> this amounts to a substantial loss of working time every year (see Table ES.1 below).

For instance, on an annual basis, the U.S. loses an equivalent of about 1.23 million working days due to insufficient sleep. This corresponds to about 9.9 million working hours. This is followed by Japan, which loses on average 0.6 million working days, or 4.8 million working hours, per year. With 0.2 million days the UK and Germany have a similar amount of working time lost, corresponding each to more than 1.65 million working hours. Among the five OECD countries examined, with about 0.08 million working days, Canada has the least working time lost due to insufficient sleep, corresponding to about 0.6 million working hours.

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<sup>1</sup> National Sleep Foundation (2013) reports the share of people sleeping less than 7 hours across five OECD countries as: Japan (56%), U.S. (45%), UK (35%), Germany (30%) and Canada (26%). See Table 1.1 in the report for more details.

Table ES.1: Total working time lost across five different OECD countries

| Country                             | U.S.      | UK        | Germany   | Japan     | Canada  |
|-------------------------------------|-----------|-----------|-----------|-----------|---------|
| Sleep: % < 6 hours                  | 18%       | 16%       | 9%        | 16%       | 6%      |
| Sleep: % 6 to 7 hours               | 27%       | 19%       | 21%       | 40%       | 20%     |
| # Full-time workers (in thousands)  | 121,490   | 22,733    | 28,965    | 47,790    | 14,559  |
| # Part time workers (in thousands)  | 27,340    | 8,296     | 11,245    | 14,000    | 3,387   |
| Days lost (full-time): < 6 hours    | 528,377   | 87,372    | 60,545    | 185,289   | 22,089  |
| Days lost (full-time): 6 to 7 hours | 479,643   | 64,447    | 90,023    | 282,009   | 41,888  |
| Days lost (part-time): < 6 hours    | 118,906   | 31,885    | 23,506    | 54,280    | 5,139   |
| Days lost (part-time): 6 to 7 hours | 107,938   | 23,519    | 34,951    | 82,614    | 9,745   |
| Days lost: total                    | 1,234,864 | 207,224   | 209,024   | 604,191   | 78,861  |
| Hours lost: total                   | 9,878,910 | 1,657,792 | 1,672,192 | 4,833,532 | 630,886 |

*Notes: sleep-per-day data based on data from the National Sleep Foundation (2013) representative survey. The proportions of people sleeping less than six and between six and seven hours have been calculated by using the weighted average among the proportions for workday and weekend sleep patterns. The numbers of full and part-time employed workers in each country comes from the OECD labour statistics database. Note that we assume 250 working days per full-time employee per year and 125 working days for part-time employees. As an example, the total days lost due to insufficient sleep in an economy are calculated by multiplying the total number of workers (full- and part-time) by the proportions of short sleepers (< 6 hours and 6 to 7 hours), multiplied by the total number of working days (full-time: 250; part-time: 125) plus the percentages of work impairment due to absenteeism and presenteeism (< 6 hours: 2.36%; 6 to 7 hours: 1.47%). To calculate the total hours lost we multiply the working days by eight hours.*

#### **4. Up to \$680 billion is lost each year across five OECD countries due to insufficient sleep**

To provide estimates of the economic costs associated with insufficient sleep we develop a bespoke macro-economic model that simulates the various agents in an economy, including individuals, firms and the government, and their interactions over time. In our analytical approach, the effect of insufficient sleep is translated into the supply of effective labour units that individuals provide in the economy. In essence, labour supply is affected through three mortality and productivity related mechanisms.

Firstly, due to insufficient sleep, people are more likely to die than if they slept seven to nine hours a night, reducing the size of the working population. Secondly, sleep deprived workers are more likely to be absent from work due to sickness or with reduced performance while at work, which leads to an efficiency loss for each unit of labour supplied in the economy. Thirdly, sub-optimal school performance in younger years due to sleep deprivation hinders an individual's skill development. We take this human capital effect into account by modelling shifts in the skill distribution at the point in time when adolescents enter the labour market.

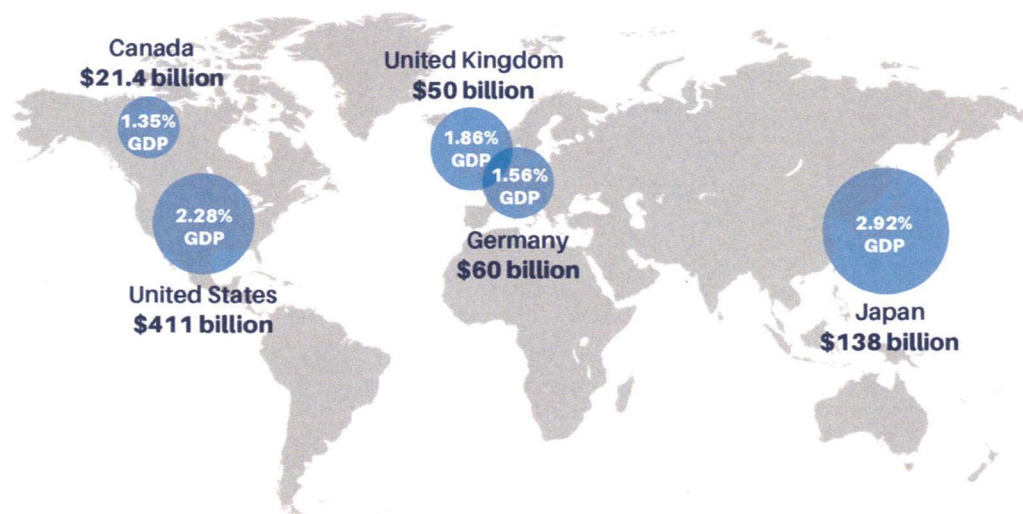
As a first step, the model simulates the economic forecast of each of the five OECD countries under consideration in the status quo (or baseline) scenario – the current proportions of people with insufficient sleep. In a second step, under different 'what if' scenarios (compared to the status quo), the model predicts how economic output and labour productivity would be affected if the proportions of short



sleepers in the economy were reduced. In other words, how much larger would be the economic output if people got sufficient sleep.

Specifically, scenario 1 in our analysis represents an optimistic ‘best-case’ scenario where all short sleepers (less than seven hours per day) in the population would sleep the recommended hours of sleep (seven to nine hours). Scenario 2 represents a less ambitious scenario by examining the economic impact if those sleeping less than six hours started sleeping six to seven hours. Scenario 3 is similar to scenario 2 but predicts the potential gains to the economy if those sleeping six to seven hours started sleeping seven to nine hours, keeping those sleeping less than six hours unaffected. The findings for scenario 1 are depicted in the figure below.

**Figure ES.1: Economic costs of insufficient sleep across five OECD countries**



*Notes: RAND Europe analysis*

Our economic predictions indicate that in absolute terms, the U.S. sustains by far the highest annual economic loss (between \$280 billion and \$411 billion currently, depending on the scenario) due to the size of its economy, followed by Japan (between \$88 billion and \$138 billion). However, relative to the size of the overall economy, the estimated loss for Japan is actually larger than for the U.S. (between 1.56 to 2.28 per cent for the U.S. and 1.86 per cent to 2.92 per cent for Japan, respectively). This is followed by the UK (1.36 per cent to 1.86 per cent), Germany (1.02 per cent to 1.56 per cent) and Canada (0.85 per cent to 1.56 per cent).

The overall costs increase slightly in magnitude over time in all subsequent years of a given scenario, as the mortality effect of insufficient sleep leads to reductions in the labour supply. That is, the death of a worker does not only affect the year the death occurs, but continues to be a part of the costs in subsequent years because of the loss of all potential future offspring. To illustrate this point, the costs of insufficient sleep in 2020 for the U.S. range from \$299 billion to \$433 billion. However, this increases by 2030, where the range is from \$318 to \$456 billion. Overall, the lowest costs are observed in scenario 2, as this scenario assumes that short sleepers between six to seven hours have no elevated mortality risks and no



higher amounts of working time lost due to absenteeism or presenteeism. The costs related to each scenario are summarised in more detail the Table ES.2 below.

**Table ES.2: Estimated annual cost in GDP terms, relative to baseline scenario**

| Year      | Country | GDP (U.S.\$ billions, 2015 prices) |       |       | GDP (%) |       |       |
|-----------|---------|------------------------------------|-------|-------|---------|-------|-------|
| Scenarios |         | 1                                  | 2     | 3     | 1       | 2     | 3     |
| Current   | U.S.    | 411                                | 280.6 | 357   | 2.28%   | 1.56% | 1.98% |
|           | UK      | 50.2                               | 36.7  | 43.2  | 1.86%   | 1.36% | 1.60% |
|           | Japan   | 138.6                              | 87.9  | 125.8 | 2.92%   | 1.86% | 2.66% |
|           | Germany | 60                                 | 39.3  | 54.8  | 1.56%   | 1.02% | 1.42% |
|           | Canada  | 21.4                               | 13.5  | 19.8  | 1.35%   | 0.85% | 1.24% |
| 2020      | U.S.    | 433.8                              | 299.4 | 377.5 | 2.40%   | 1.66% | 2.09% |
|           | UK      | 53.8                               | 40    | 46.4  | 1.99%   | 1.48% | 1.72% |
|           | Japan   | 145.9                              | 93.6  | 132.3 | 3.08%   | 1.98% | 2.79% |
|           | Germany | 62.3                               | 40.9  | 56.5  | 1.61%   | 1.06% | 1.47% |
|           | Canada  | 21.9                               | 13.9  | 20.3  | 1.38%   | 0.88% | 1.28% |
| 2025      | U.S.    | 456.1                              | 318.6 | 396.9 | 2.53%   | 1.77% | 2.20% |
|           | UK      | 57.6                               | 43.3  | 49.7  | 2.13%   | 1.60% | 1.84% |
|           | Japan   | 151.7                              | 98.3  | 137.5 | 3.20%   | 2.07% | 2.90% |
|           | Germany | 64.7                               | 42.6  | 58.6  | 1.68%   | 1.10% | 1.52% |
|           | Canada  | 22.5                               | 14.4  | 20.8  | 1.42%   | 0.91% | 1.31% |
| 2030      | U.S.    | 467.7                              | 330.0 | 406.9 | 2.59%   | 1.83% | 2.26% |
|           | UK      | 58.7                               | 44.1  | 50.6  | 2.17%   | 1.63% | 1.87% |
|           | Japan   | 156.2                              | 101.4 | 141.7 | 3.30%   | 2.14% | 2.99% |
|           | Germany | 69.1                               | 46.6  | 62.9  | 1.79%   | 1.21% | 1.63% |
|           | Canada  | 23.4                               | 15.1  | 21.6  | 1.47%   | 0.95% | 1.36% |

The findings of the economic analysis in this report suggest, lower productivity levels and higher mortality risks related to insufficient sleep can result in substantial economic losses to modern economies. For instance, insufficient sleep among their populations cost the five OECD countries under consideration up to \$680 billion of economic output every year. These costs rise over time, even if we assume constant proportions of short sleepers in the future. In summary, sleep deprivation adversely affects individuals through negative effects on their health and wellbeing and is also costly for employers due to lost working time from its employees, which is associated with large economic losses. Therefore, solving the problem of insufficient sleep represents a potential ‘win-win’ situation for individuals, employers and the wider society.

### ***5. What can be done to solve the problem of insufficient sleep?***

To improve sleep outcomes among the wider population, this report outlines a number of recommendations for individuals, employers and public authorities. Some of the key recommendations are summarised in the Table ES.3 below.

**Table ES.3: Recommendations for individuals, employers and public authorities to improve sleep outcomes**

| Recommendation   | Description  |
|--|--|
| <i>Recommendations targeted at individuals</i>                                 |  |
| 1. Set a consistent wake-up time.  | Individuals may achieve better sleep outcomes by making sure they wake up at a consistent time.  |
| 2. Limit the use of electronic devices before bedtime.                         | Individuals may achieve better sleep outcomes minimising the time spent using electronic devices and the overall amount of screen time, particularly shortly before bedtime. The use of screens in the evening may suppress people's melatonin levels, a hormone which is crucial for the control of sleeping and waking cycles. |
| 3. Limit the consumption of substances which may impair sleep quality.         | Sleep outcomes can be improved by avoiding or minimise the consumption of substances close to bedtime, including caffeine, alcohol, and nicotine.  |
| 4. Exercise.   | Physical activity has been demonstrated to be associated with improved sleep outcomes.   |
| <i>Recommendations targeting employers</i>                                     |  |
| 5. Recognise the importance of sleep and the employer's role in its promotion. | Employers should recognise the importance of sleep and the adverse outcomes both for individuals and businesses stemming from insufficient sleep. In some instances this may require a cultural change in organisational thinking.   |
| 6. Provide facilities and amenities that help employees with sleep hygiene.    | Employers can put in place arrangements to support their staff's daily routines with the aim of improving their sleep outcomes.  |
| 7. Discourage the extended use of electronic devices.                          | Employers may signal limits on staff's expected availability after working hours or by introducing policies limiting after-hours and out-of-office communications.   |
| <i>Recommendations targeting public authorities</i>                            |  |
| 8. Support health professionals in providing sleep-related help.               | Awareness campaigns and wider support activities should be aimed at professionals so that they are best equipped to assist individuals suffering from sleep disorders.   |
| 9. Introduce later school starting times.                                      | Public authorities can help promote more effective schedules by introducing delayed school starts.   |